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Research Note

Radiographic Imaging of the Rat Tapeworm, *Hymenolepis diminuta*

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ABSTRACT: The model of *Hymenolepis diminuta* Rudolphi in laboratory rats was used to investigate potential applications of radiographic imaging in the diagnosis and/or study of tapeworm infections. Radiographic imaging successfully demonstrated the presence of *H. diminuta* in the rat intestine in the presence of a water-soluble iodinated radiographic contrast medium, Gastrografin®. Even single worms and small segments of proglottids could be detected. Optimal imaging was achieved with an exposure factor of 3.75 mAs at 54 kVp with mammography film. Visualization was improved by fasting the rat host to effect the elimination of food and fecal shadows. Elaboration of this methodology may prove useful in basic research and the incidental diagnosis of human tapeworm infection by permitting rapid diagnosis of prepatent infection, thereby providing a useful tool in efficacy testing of anthelmintics when assessing prepatent success and temporal aspects of drug activity.

KEY WORDS: radiographic imaging, tapeworm, Cestoda, *Hymenolepis diminuta,* laboratory rat, diagnosis, Gastrografin, x-ray.

Hymenolepis diminuta Rudolphi, 1819, is a cosmopolitan tapeworm of rats that occasionally infects humans. A closely related species, *Hymenolepis nana* Siebold, 1852 (syn. *Vampirolepis nana* (Siebold, 1852) Spassky, 1954), is one of the world's most common tapeworms and is especially prevalent among children, with prevalences of up to 97.3% having been reported among humans (Roberts and Janovy, 1996). Although light infections of *H. nana* are asymptomatic, heavy infections may be characterized by abdominal pain, diarrhea, headache, dizziness, anorexia, and various other nonspecific symptoms characteristic of intestinal cestodiasis (Markell et al., 1999). Sehr (1974) indicated that roentgenological recognition of *Hymenolepis* spp. in humans is relatively difficult and that radiographic findings are mostly negative or that only nonpathognomonic changes can be seen in the mucosal pattern of the intestine. Gold and Meyers (1977) reported the radiographic diagnosis of a human infection with the beef tapeworm, *Taenia saginata* Goeze, 1782, in the small intestine of a 34 year old male patient. Following a barium enema, "small bowel examination clearly outlined an intraluminal, essentially continuous linear filling defect in the distal jejunum and ileum extending into the proximal descending colon" (Gold and Meyers 1977, p. 493). In this instance, the worm extended into the proximal descending colon. It was concluded that tapeworm infection may be initially recognized on barium enema study. Unfortunately, barium enema studies would seldom be expected to be of great value in diagnosis because tapeworms are normally restricted to the small intestine. Aside from this information, little is known about radiographic imaging of tapeworm infections and, specifically, infection with *Hymenolepis* spp., although infections with other helminth species such as *Schistosoma haematobium* (Bilharz, 1852) Weinland, 1858, *Ancylostoma duodenale* (Dubini, 1843) Creplin, 1845, and *Ascaris lumbricoides* Linnaeus, 1758, are sometimes diagnosed in the course of routine radiographic examination (Reeder and Palmer, 1989). We utilized the laboratory model of *Hymenolepis diminuta* in rats to investigate potential applications of radiographic imaging in the diagnosis and/or study of *Hymenolepis* spp. The goals of this study were to determine whether infection of *H. diminuta* in rats can be diagnosed using radiography, to determine the optimal methodology for visualization of worms, and to determine what information can be obtained from radiographs of infected animals.

Laboratory infection of rats was accomplished by feeding 3 female Wistar rats 10, 10, and 30 cysticercoids, respectively, of *H. diminuta* taken from our laboratory colony of the grain beetle,

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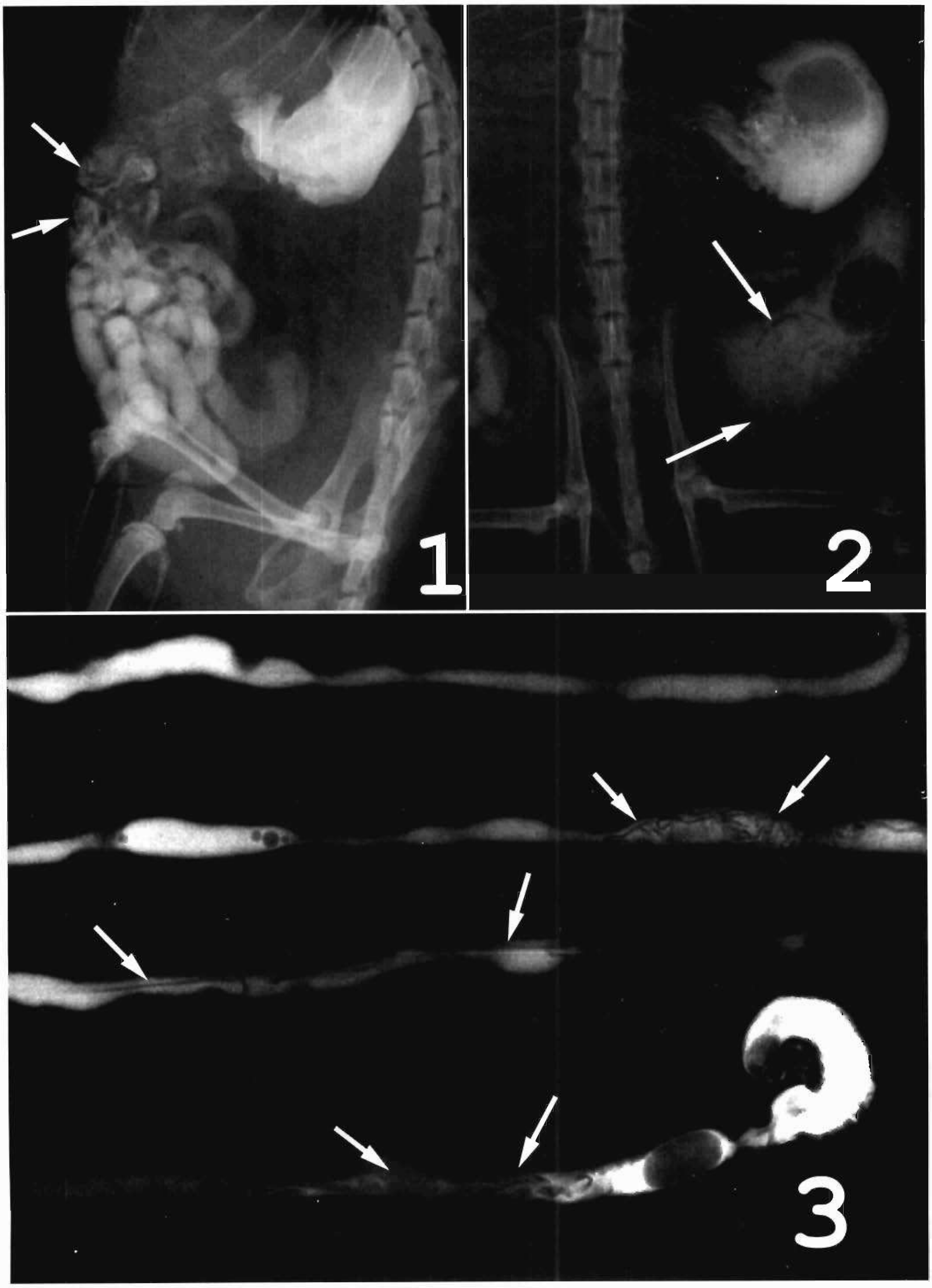
Tenebrio molitar Linnaeus, 1758. Radiographic studies were conducted at 21 days postinfection. Baseline methodologies were established using an uninfected control rat. Each rat was lightly anesthetized with the inhalation anesthesia Halothane® (Halocarbon Laboratories, River Edge, New Jersey), and a 1.5 cc bolus of a water-soluble iodinated radiographic contrast medium, diatrizoate meglumine sodium solution (Gastrografin®; Squibb Diagnostics, Princeton, New Jersey), was administered through a 6 French teflon catheter inserted into the rat's stomach. X-rays were taken at various exposure factors and with various films to determine the optimal radiographic technique. Optimal imaging was achieved with an exposure factor of 3.75 mAs at 54 kVp with Kodak Min-R® single-emulsion mammography film. The rat was placed in a posterior–anterior or dorsal–ventral position and x-rays were taken at 5-min intervals to establish the length of time required for the contrast medium to reach the ileocecal junction. By 30 min, Gastrografin had filled the entire small intestine. Food material and fecal shadows were evident in the control rat. Next, Gastrografin was administered to Rat I, which had been fed 10 cysticercoids. At 30 min, posterior–anterior and lateral x-rays were taken. Based on the lateral projections, worms were evident in the anterior portion of the small intestine (Fig. 1). Rat I was killed in a carbon dioxide chamber, and the entire gastrointestinal tract, excluding the esophagus, was removed, coiled onto a mammography cassette, and x-rayed. From the x-ray, predictions were made concerning the position and relative abundance of worms. The intestine was then longitudinally dissected and the locations of the 10 adult tapeworms were noted and compared to the predictions. It was concluded that even in the presence of food in the intestine, infection can be diagnosed and inference made regarding the location and relative abundance of worms.

Twenty-four hours after administration of Gastrografin to another infected rat, x-rays were taken to determine whether the contrast medium was taken up by or had adhered to the worms, thereby creating an outline of the worms in the alimentary canal, as may be the case with *A. lumbricoides* (Reeder and Palmer, 1989). Worms could not be visualized in x-rays of the small intestine when Gastrografin was lacking, suggesting that worms do not absorb the contrast medium. This is consistent with the observations of Gold and Meyers (1977) regarding human infection with *T. saginata* in association with a barium enema.

To determine whether fasting would improve the conditions for visualization of worms, rats were not fed for 24 hr prior to the administration of Gastrografin and radiographic examination using the methodologies outlined above. After fasting, the control rat exhibited gas bubbles, but food and fecal shadows were lacking. Radiologic examination of Rat II, which had been fed 10 cysticercoids, revealed that visualization of worms was improved by fasting because of the elimination of food and fecal shadows. The posterior–anterior projection of Rat II is shown in Figure 2. Interestingly, x-rays suggested that worms were present in the cecum. Postmortem examination confirmed this x-ray finding. The rat was killed and the intestine was removed and coiled onto a mammography cassette. Based on the x-ray (Fig. 3), predictions were made concerning the position and relative abundance of worms. The intestine was longitudinally dissected and the numbers and locations of worms were confirmed. The procedure was repeated with Rat III, which had been fed 30 cysticercoids. Even small sections of proglottids could be detected in the large intestine.

We have shown that radiographic imaging can successfully demonstrate the presence of *H. diminuta* in the rat intestine. It is possible that these findings can be extended to human infections of *H. nana*. If so, this could be useful in the incidental diagnosis of human infection in the course of routine radiographic imaging. This could be especially valuable in areas of high parasite prevalence, such as Moscow, where prevalences as high as 97.3% have been reported (Karnaukov and Laskovenko, 1984; see Roberts and Janovy, 1996). Because of the size differences of the hosts and the worms, more information concerning the radiographic imaging of *Hymenolepis* spp. in humans is warranted to better define the radiographic presentation of human infection and the utility of this methodology in diagnosis.

In addition to potential human clinical applications, this technique provides rapid diagnosis of prepatent infection without having to kill the animal. This may prove useful in studying the basic biology of *H. diminuta,* which exhibits complex emigrations and migrations within the



Figures 1–3. Radiographic imaging of *Hymenolepis diminuta*. Scale is actual size. 1. Lateral projection of Rat I showing infection of *Hymenolepis diminuta*. Arrows indicate aggregation of worms in the small intestine. 2. Posterior–anterior projection of Rat II showing infection of *Hymenolepis diminuta*. Arrows indicate worms in cecum. 3. Radiograph of intestine removed from Rat II, showing infection of *Hymenolepis diminuta*. Arrows indicate worms in a substantial portion of the small intestine.

rat intestine (Mettrick and Podesta, 1974). This may also be a useful tool in efficacy testing of anthelmintics when assessing prepatent success and temporal aspects of drug activity.

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Research Note

Helminths of Two Lizards, *Barisia imbricata* and *Gerrhonotus ophiurus* (Sauria: Anguidae), from Mexico

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ABSTRACT: The gastrointestinal tracts of 37 *Barisia imbricata* (Wiegmann) and 54 *Gerrhonotus ophiurus* Cope from Mexico were examined for helminths. The helminth fauna of *B. imbricata* consisted of 4 species of nematodes: *Cosmocercoides variabilis* (Harwood), *Oswaldocruzia pipiens* Walton, *Physaloptera retusa* Rudolphi, and *Raillietnema brachyspiculatum* Bursey, Goldberg, Salgado-Maldonado, and Méndez-de la Cruz. *Gerrhonotus ophiurus* harbored 1 trematode species, *Brachycoelium salamandrae* (Frölich), and 2 nematode species, *Cosmocercoides variabilis* and *Physaloptera retusa*. All represent new host records. With the exception of *R. brachyspiculatum*, all these helminths are generalists, which are widely distributed in other amphibian and reptile hosts.

KEY WORDS: lizards, Sauria, *Barisia imbricata*, *Gerrhonotus ophiurus*, Anguidae, Trematoda, *Brachycoelium salamandrae*, Nematoda, *Cosmocercoides variabilis*, *Oswaldocruzia pipiens*, *Physaloptera retusa*, *Raillietnema brachyspiculatum*, Mexico.

Barisia imbricata (Wiegmann, 1828) occurs in highland pine forests throughout Mexico west of the Isthmus of Tehuantepec (Good, 1988). *Gerrhonotus ophiurus* Cope, 1866, occurs in the Mexican states of Hidalgo, Puebla, San Luis Potosí, and Veracruz (Good, 1994). There are, to our knowledge, no reports of helminths from these species. We report here the helminths from populations of *B. imbricata* and *G. ophiurus*.

Thirty-seven *B. imbricata* deposited in the herpetology collection (ENEPI) of the Escuela Nacional de Estudios Profesionales Iztacala, Universidad Nacional Autónoma de México (UNAM) were examined: 23 from Estado de

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